EDITORIAL.

IN AN article on "Englacial Drift," in the July number of the American Geologist, my friend, Mr. Warren Upham, referring to my article in the first number of this Journal on the Englacial Drift of the Mississippi Basin, takes exception to the impression conveyed respecting his views in the matter of rising glacial currents. The present writer, he says, "several times speaks of the opinions of writers who believe in the considerable volume of the englacial drift, as if they supposed the glacial currents to move gradually upward from the ground to the ice surface. Such a supposition, however, seems to me quite untenable. Instead, in my own writings and those of most, if not all, of these authors, the exposure of the drift on the surface of the ice-sheet near its border, whence much of it was washed away to form the eskers, kames, and valley drift, is ascribed wholly to the superficial melting of the ice sheet, which is called ablation." I very much regret to have given expression, or to have seemed to have given expression, to the views of these writers in any other terms than they would themselves have chosen, and I cheerfully reproduce the corrective statement which Mr. Upham makes. Until my attention was called to the matter, no other interpretation of the views of these writers than that the supposed rising glacial currents moved on gradually to the surface of the ice occurred to me as possible, as no logical stopping place short of that suggested itself. I do not see any other consistent view now, but that does not affect the obligation to present accurately the views actually held. I hope these writers will credit me with attributing to them what seemed to be the most logical aspect of the hypothesis entertained by them. The supposed upward movement is attributed to differential motion

between the successive layers of ice, as stated by Mr. Upham on pages 38-9 of the article referred to (quoted below). This differential motion arises from friction at the bottom and extends to the summit. It was natural, therefore, to take it for granted that the supposed rising current extended as far as its postulated cause. It was to be assumed, of course, that the current would rise less rapidly in the upper part if the difference of movement of successive ice layers were less there than below, but it would seem that the rise must be supposed to continue *at some rate* so long as the differential motion continued, *i. e.*, until the surface was reached. The accession of snow-fall within the zone of accumulation would, to be sure, prevent erratics from reaching the new surface thus continually formed, but it would not prevent their reaching the surface in the zone of wastage. It is this latter zone with which our problems of deposition and many of our problems of derivation have chiefly to do. The career of some erratics is wholly confined to it. It goes without saying that ablation brings the surface down and is a factor in every exposure within the zone of wastage, but this does not prevent the erratics rising (by hypothesis) until they meet it. This conception of rising currents met by a plane of ablation I supposed without question to be that entertained by Mr. Upham and others. To be sure, in a strict and complete statement under this view the exposure of englacial erratics at the surface would be attributed to the joint result of the upward movement and the downward melting, but the liberties of brief and convenient statement would permit it to be referred to in terms of either factor, and I have interpreted the expressions of these writers on this basis. The correction does not, so far as I can see, in any serious way affect the main question under discussion. If there were rising currents bearing erratics to heights of 500 or 1000 feet above the base of the ice the result in ultimate deposition would be essentially the same as if the currents rose to the surface. If the rising currents are a misinterpretation, it is immaterial whether they be supposed to bear erratics to varying heights up to 500 or 1000 feet, whence these erratics move forward parallel with the base of the

ice, or whether they be supposed to continue to rise (more and more slowly) till they meet the descending plane of ablation.

If currents rise by reason of differential movements to certain heights, but not beyond them, notwithstanding the extension of the differential movements all the way up to the surface, a very distinct statement of this limitation and of the dynamics involved, qualitative and quantitative, would be appropriate. Perhaps such an explanation is intended in the following quotation from Mr. Upham, which I introduce to give ampler expression to his views, though I dissent from his interpretations of the crevasses of the alpine glaciers and of the esker, Bird's Hill, as well as from his fundamental proposition.

"The conditions of the flowing ice which seem to me to have been efficacious to carry drift upward into it from tracts of plane or only moderately undulating contour, were the more rapid onflow of the ice-sheet in its upper and central parts and even in the portion near the ground but not in contact with it, than upon the bed of the ice-sheet where its movement was much retarded by friction. A very good analogy with the slowly rising currents which I believe to have existed in many portions of the base of the ice-sheet is afforded by the edges of alpine glaciers, where the crevasses extending diagonally up stream into the glacier testify that the movement of its friction-hindered border is from the side of the valley into the ice mass. But the arched surface of the glacier and the great supply of its central current prevent the drift so worn off and borne away from being carried into the axial portion of the ice stream. Similarly the steady accession to the mass of the ice-sheet over any place by onflow from its thicker central part and by the accumulating snowfall forbade the drift of the upwardly moving basal current from being carried far into the ice in comparison with its total thickness. The evidence of the esker called Bird's Hill, near Winnipeg, Manitoba, shows that much englacial drift had there been uplifted from a nearly level country to a height of more than 500

feet in the ice-sheet.[1] Probably some of the englacial drift there was as high as 1,000 feet or more in the ice, but doubtless a larger part was below than above the altitude of 500 feet; and this was on an area where the ice-sheet had attained probably a thickness of 5,000 or 6,000 feet, its lower fifth or sixth part bearing considerable enclosed drift. In like manner the outer portions of the ice-sheet, where its thickness was less, had probably at its time of culmination no englacial drift above its lower sixth or fourth or third part. Whatever boulders and other drift became incorporated in the higher portion of the zone reached by the currents flowing upward would be thence carried forward in some regions, as from the Huronian and Laurentian areas north of Lake Huron to the boulder belts in Illinois, Indiana and Ohio, described by Chamberlin[2] without intermixture with other englacial drift brought into the ice by less powerful currents on all the intervening extent, which in the case mentioned is about five hundred miles."[3]

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[1] Geol. and Nat. Hist. Survey of Canada, Annual Report, new series, vol. iv., for 1888–89, pages 36–42E.

[2] "Boulder Belts distinguished from Boulder Trains—their Origin and Significance," Bulletin, G. S. A., vol. i, pp. 27–31. "The Nature of the Englacial Drift of the Mississippi Basin," Journal of Geology, vol. i, pp. 47–60.

[3] The American Geologist, vol. xii, No. 1, July, 1893, pp. 38–39.